

DOT-HS-801 953

# **EFFECTIVENESS OF VARIOUS SAFETY BELT WARNING SYSTEMS**

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16. Abstract  This observation study among rental car customers was conducted at the Sky Harbor Airport, Phoenix, Arizona, during the period August 4 - December 12, 1975. Overall objectives were (1) to determine if the warning system now required on 1975 and 1976 cars is effective in increasing safety belt usage, and (2) to determine the effectiveness of various other types of warning systems allowable under P.L. 93-492. Study phases consisted of the following: (a) select study site and obtain cooperation of rental car agencies and airport officials; (b) recruit and train field personnel; (c) modify and equip rental cars with various warning systems; (d) observe and record safety belt usage in returning rental cars over a 19-week period; and (e) inspect returning cars to determine that the various systems were operating properly. Results show that the present system required by Standard 208 is not effective in increasing safety belt usage. Most effective system for increasing usage is one that includes, in addition to the present equipment: (1) a reminder light that does not go off unless the belt is fastened; and (2) a sequential logic system that requires the driver to first sit on the seat and second to buckle the belt.					
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## SUMMARY

### Introduction and Purpose

The safety belt warning system required by Federal Motor Vehicle Safety Standard #208 in 1972 and 1973 model cars initially increased belt usage but these gains in usage diminished with time. The safety belt interlock system required by Federal standards on 1974 cars substantially increased usage which also decreased with time but not to the same extent as experienced with the 1972 warning system. Because this interlock system was considered unacceptable for a variety of reasons by members of the public, Congress adopted regulations that prevented Federal requirements for safety belt interlocks and continuous buzzer warning systems. Consequently, the new warning system required on 1975 and 1976 cars consists of a light and buzzer system that goes off automatically after 4-8 seconds regardless of whether or not the belts are fastened. The purpose of this study is (1) to determine if this new system is effective in increasing usage, and (2) to determine the effectiveness of various other types of warning systems allowable under Congressional requirements.

### Research Approach

The basic research design called for observing actual usage of safety belts among drivers and front seat passengers in 1975 model year rental cars that were equipped with six different warning systems. These systems were installed in 818 rental cars at the Sky Harbor Airport, Phoenix, Arizona.

Observers were carefully trained by an ORC staff person to determine accurately the safety belt usage to be reported. Observers worked under the direction of a local supervisor throughout the survey period.

Front seat occupants in the specially modified rental cars being returned to the airport were observed for 10 hours a day, 7 days a week, during a 19-week period, August 4 - December 12, 1975. A total of 5,429 observations were made during the survey period of rental cars in which the use-inducing systems were found to be working. The modified use-inducing system in each rental car being returned was inspected by trained personnel immediately after the customer left the car at the drop-off area. Thus, the data reported for safety belt usage are based on the 5,429 observations of rental cars in which the warning systems were operating properly.

### Overall Findings

Among the six use-inducing systems tested, safety belt usage is at a significantly higher rate than the control group (cars with no operating warning systems) in the following two types of use-inducing systems:

- Vehicles which include a 7-8 second buzzer, a continuous warning light, and a sequential logic circuit
- Vehicles which include a 7-8 second intermittent buzzer, a flashing continuous warning light, and a sequential logic circuit

Safety belt usage rates for each of the six use-inducing systems and the control group are shown in the figure below:

Figure 1

<u>Type System</u>	<u>Percent Observed Usage</u>		<u>Total</u>	<u>N</u>
	<u>Lap and Shoulder</u>	<u>Lap Only</u>		
No WS operating	12.8	+1.7	14.5	1,394
7-8 sec buz, seq, cont lt	21.6	+1.9	23.5 (s)	583
7-8 sec seq, inter buz, cont fl lt	21.3	+1.7	23.0 (s)	1,050
7-8 sec lt & buz, both seq	15.5	+1.1	16.6	848
1975 WS (7-8 sec duration)	13.2	+1.1	14.3	637
7-8 sec buz, cont lt	13.1	+1.4	13.5	222
1975 WS (4-5 sec duration)	11.9	+1.9	12.8	695

S = Sig. higher than control

### Conclusions

1. Present system required is not effective.
2. To increase usage, need both continuous light and sequential system.

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ALBERT WESTEFELD  
BENJAMIN M. PHILLIPS

## INTRODUCTION AND METHODOLOGY

### Introduction

It is generally recognized that the utilization of the safety belts already in passenger cars would constitute the most cost-effective, single measure to reduce fatalities and injuries in motor vehicle crashes.

Although seat belts were required in passenger vehicles as early as 1964, the rate of safety belt usage was discouragingly low. As a first step directed to increase wearing rates, NHTSA initiated a broad spectrum of research activities designed to explore all reasonable means of achieving this goal. One of these initial projects explored the motivations and circumstances surrounding both the use and nonuse of safety belts. One important finding of this research was that safety belts at that time were needlessly complex, uncomfortable, and inconvenient. Another finding indicated a significant proportion of people didn't wear belts because they needed to be reminded.

These results contributed to NHTSA's establishing a requirement for light-and-buzzer reminder systems for "1972½" and 1973 automobiles. These "use-inducing" reminder systems significantly increased belt wearing rates, as shown by a number of independent studies, from on the order of 20% to approximately 40%. Unfortunately, these tended to decline with time and as the cars got older.

The simple sensor system used to activate the belt-use reminder in 1972-73 cars could be bypassed easily; and, furthermore, once the belt was left in an extended position or left buckled, the reminder system would never be activated again. To deal with this problem, the 1974 models incorporated a "sequential logic system." This system essentially required that the belt be fastened only after the appropriate seat had been occupied, in order to be "satisfied" that the belt was being used. The starter-interlock feature prevented the engine from starting unless the logic system was "satisfied" that the front belts were fastened when the corresponding seat positions were occupied. Except for the sequential logic, the warning light and buzzer used in 1974 cars were the same as in the 1972-73 models.

The interlock system was not well accepted by the public, with many individuals resenting the system because they felt they were being forced to fasten their safety belts. Some of the more active of this group sent letters of complaint to their Congressmen and, in the 1974 Motor Vehicle and School Bus Amendments passed by Congress, NHTSA was prohibited from having a standard which required an interlock system or a continuous buzzer (defined as one which sounded for more than 8 seconds after the ignition was turned to the "on" or "start" position.)

In response, NHTSA changed the standard so that cars produced after February of 1975 had a warning system that consisted of: (1) a 4-8 second warning light that is activated whenever the ignition is turned on, regardless of whether or not the belt has been fastened, and (2) a buzzer that will sound for 4-8 seconds unless the driver's belt is fastened.

The purpose of this study is: (1) to determine if this new system is effective in increasing usage, and (2) to determine the effectiveness of various other types of warning systems allowable under Congressional requirements.

### Methodology

To ascertain the relative effectiveness of the various safety belt use-inducing systems as defined in Contract DOT-HS-5-01154, a number of tasks were performed. The major tasks were:

- Select study site and obtain cooperation of the rental car companies and airport officials
- Recruit and train observers
- Modify and equip rental cars in accordance with the experimental design
- Observe safety belt usage in these rental cars over a 19-week period
- Inspect these returning vehicles to determine and record whether or not the warning system was operating in accordance with specifications

- Select Study Site and Obtain Cooperation

It was determined, for a variety of reasons, that the most cost-effective method of accomplishing the study objectives was to equip a number of rental cars with the systems to be examined. By studying rental cars at an airport, it was possible to amass a large amount of data in a relatively short time. Similar studies involving rental cars have been successfully undertaken in the past under the following titles:

Effectiveness of Safety Belt Warning and Interlock Systems, National Analysts, Inc., DOT-HS-800859, April 1975

Safety Belt Interlock System: Usage Survey, Opinion Research Corporation, DOT-HS-801594, May 1975

Members of NHTSA obtained an initial agreement of cooperation from corporate headquarters of the three largest rental car companies -- Avis, Hertz, and National. This paved the way for obtaining the cooperation of the local managers of the airport selected for the study.

Although a number of airport sites were considered, the Sky Harbor Airport in Phoenix, Arizona, was selected as the study site since it met the following criteria:

- (1) A good "physical set-up," that is, the cars were returned to the three rental car companies via one road or entrance and at a certain point had to stop or slow down enough so that observers could see and record whether the driver and front seat passenger were wearing the lap and shoulder belt, the lap belt only, or neither.
- (2) Due to its location, it minimized the possibility that the cars modified would become "lost," i.e., dropped off at another city and left there.
- (3) Each company's rental car fleet of 1975 models was of adequate size.
- (4) Local managers who would be willing to cooperate in the study by agreeing to let a specified number of their cars be modified and identified with color stickers.
- (5) Airport officials who would be willing to cooperate and permit the study to be conducted at their facilities.

- Recruit and Train Observers

The ORC Project Manager had the primary responsibility for the hiring and training of a local supervisor and other field personnel who were involved in the study.

Individuals selected for the study were subjected to a formal training session which lasted for a full day and included on-site training. The training stressed the need for accurate observing of safety belt usage, how to record data on the observation form, and a detailed description of the various warning systems being studied. The ORC Project Manager supervised the overall operation for the first two weeks, after which the local supervisor assumed the supervisory functions. Two surprise visits were made to the study site by ORC staff personnel to make certain that all field personnel were performing their tasks in a proper manner. NHTSA personnel also made trips to the study site during the survey period to review the field operation.

- Modify/Equip Rental Cars in Accordance with the Proposed Experimental Design

As mentioned previously, a total of 818 rental cars were selected from the fleets of Avis, Hertz, and National. All of these rental cars had originally been equipped with an interlock and sequential logic system. The original electronic devices or modules were taken out of the car and replaced with the new modules developed by Stewart-Warner to effect the various modifications called for by the experimental design. Following is a description of how each system performed when the driver of the rental car seated himself and turned the ignition to the "on" position, depending upon whether he fastened the safety belt or did not fasten it.

	<u>No. of Cars Modified</u>
(a) <u>No Use-Inducing System (Control Group)</u>	150
Safety belt fastened:	
Reminder light and buzzer do not go on.	
Safety belt not fastened:	
Reminder light and buzzer do not go on.	

No. of Cars  
Modified

- (b) 1975 Warning System (7-8 Second Buzzer  
and Light), Nonsequential 91

Safety belt fastened:

Reminder light goes on for 7-8 seconds and then goes off. Buzzer does not go on.

Safety belt not fastened:

Reminder light and buzzer go on for 7-8 seconds and then go off.

- (c) 1975 Warning System (4-5 Second Buzzer  
and Light), Nonsequential 79

Safety belt fastened:

Reminder light goes on for 4-5 seconds and then goes off. Buzzer does not go on.

Safety belt not fastened:

Reminder light and buzzer go on for 4-5 seconds and then go off.

- (d) 7-8 Second Buzzer and Continuous Light,  
Sequential 148

Safety belt fastened:

Reminder light and buzzer do not go on.

Safety belt not fastened:

Reminder light goes on and stays on.  
Buzzer goes on for 7-8 seconds and then goes off.

Note: The sequential logic system requires the driver to first sit on the seat and second to fasten the belt. (This latter feature is designed to prevent the belt from being buckled and left that way.)

	<u>No. of Cars Modified</u>
(e) <u>7-8 Second Intermittent Buzzer and Continuous Flashing Light, Sequential</u>	143
<p>Safety belt fastened: Reminder light and buzzer do not go on.</p> <p>Safety belt <u>not</u> fastened: A <u>flashing</u> reminder light goes on and stays on. A buzzer with <u>intermittent sound</u> goes on for 7-8 seconds and then goes off.</p> <p>Includes sequential logic (see explanation under modification (d) above).</p>	
(f) <u>7-8 Second Buzzer and Light, Sequential</u>	131
<p>Safety belt fastened: Reminder light goes on for 7-8 seconds and then goes off. Buzzer does not go on.</p> <p>Safety belt <u>not</u> fastened: Reminder light goes on for 7-8 seconds and then goes off. Buzzer goes on for 7-8 seconds and then goes off.</p> <p>Includes sequential logic (see explanation under modification (d) above).</p>	
(g) <u>7-8 Second Buzzer and Continuous Light, Nonsequential</u>	76
<p>Safety belt fastened: Reminder light and buzzer do not go on.</p> <p>Safety belt <u>not</u> fastened: Reminder light goes on and stays on. Buzzer goes on for 7-8 seconds and then goes off.</p>	

● Equipment

ORC contracted with the Stewart-Warner Electronics Division, Chicago, Illinois, to provide the hardware (modules) needed to activate the six different use-inducing systems in accordance with contract specifications. Interlock modules were modified and tested and then shipped to the ORC field supervisor in Phoenix. Stewart-Warner provided ORC with detailed written instructions on the removal of the existing modules and the installation of the modified modules in Chrysler, Ford, and General Motors cars. The interlock modules which were modified by Stewart-Warner in accordance with the experimental design were the same type as the ones used by each of the three car manufacturers. Thus, it was possible to exchange the existing module with the modified module to obtain the desired result.

The physical installation of the modules was carried out by trained personnel working under the direction of the local ORC supervisor. The installation task took place at the storage areas of each of the rental car companies. After installation of the module, the installer conducted appropriate tests to make certain that the use-inducing system was operating as per contract specifications. When satisfied that the system was working properly, the installer placed round (1-1/4") color stickers on the inside of the front and rear windows and on the front and rear bumpers. Thus, each modification could be identified by the color sticker on the car during the observation phase. For each car modified, certain other detailed records were kept, such as license number, make, type of seat, etc.

In selecting cars for modification, every effort was made to obtain equal proportions of Chrysler, Ford, and General Motors cars. Inventory lists furnished to ORC by the rental car companies enabled us to maintain a good balance by type of use-inducing system and manufacturer, as shown in the following table:

Figure 2

MODIFICATIONS BY MANUFACTURER

<u>Type System</u>	<u>Total</u>	<u>Chrysler</u>	<u>Ford</u>	<u>G.M.</u>
Total	818	270	270	278
No WS operating	150	50	50	50
1975 WS (7-8 sec duration)	91	27	28	36
1975 WS (4-5 sec duration)	79	26	26	27
7-8 sec lt & buz, both seq	148	51	46	51
7-8 sec buz, cont lt	76	23	24	29
7-8 sec seq, inter buz, cont fl lt	143	50	49	44
7-8 sec buz, seq, cont lt	131	43	47	41

● Observation/Inspection Phase

Prior to the modification task just described, an observation study was conducted for one week of all unmodified rental cars being returned. The "base period" study proved to be invaluable in that it acquainted field personnel with the different tasks to be performed, where best to position oneself for observing, what were the peak return hours, etc. Usage data collected for the base period on unmodified cars compare closely with usage data for unmodified cars in the full study.

<u>Usage</u>	<u>Unmodified Cars</u>	
	<u>Base Period (1-week)</u>	<u>Full Study (18-week)</u>
Lap and shoulder	16.0%	12.8%
Lap only	2.1	1.7
Both off	81.9	85.5

The full scale study, which was conducted 10 hours a day, 7 days a week, for 18 weeks, included two shifts of field personnel. Each shift included three observers -- one at the Avis return area, one at the Hertz return area, and one at the National return area. The first shift ran from 9 AM until 2 PM, the second shift from 2 PM to 7 PM.

Field personnel were provided with observation forms at the start of each shift. They recorded the sex and safety belt usage of the driver and the front outboard passenger, the color code on the rear or front window, the license number, make of car, and seat type. After the observation data were recorded, the observer asked the driver of the rental car whether or not he/she had stopped at the main entrance to the airport terminal before he/she drove into the return area.<sup>1/</sup> This information was also recorded on the observation form.

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<sup>1/</sup> This information was needed because we wished to check on whether people who stopped at the terminal were significantly lower in safety belt usage at the subsequent observation point than those who did not stop. Comparison of usage rates for the two groups showed that they could be combined and all cases used in the analysis. The table opposite shows usage data for each of the seven systems both including and excluding rental car customers who stopped at the terminal before returning the car to the drop-off area.

SAFETY BELT USAGE, BY TYPE OF WARNING SYSTEM  
ANALYSIS BY TERMINAL STOPS

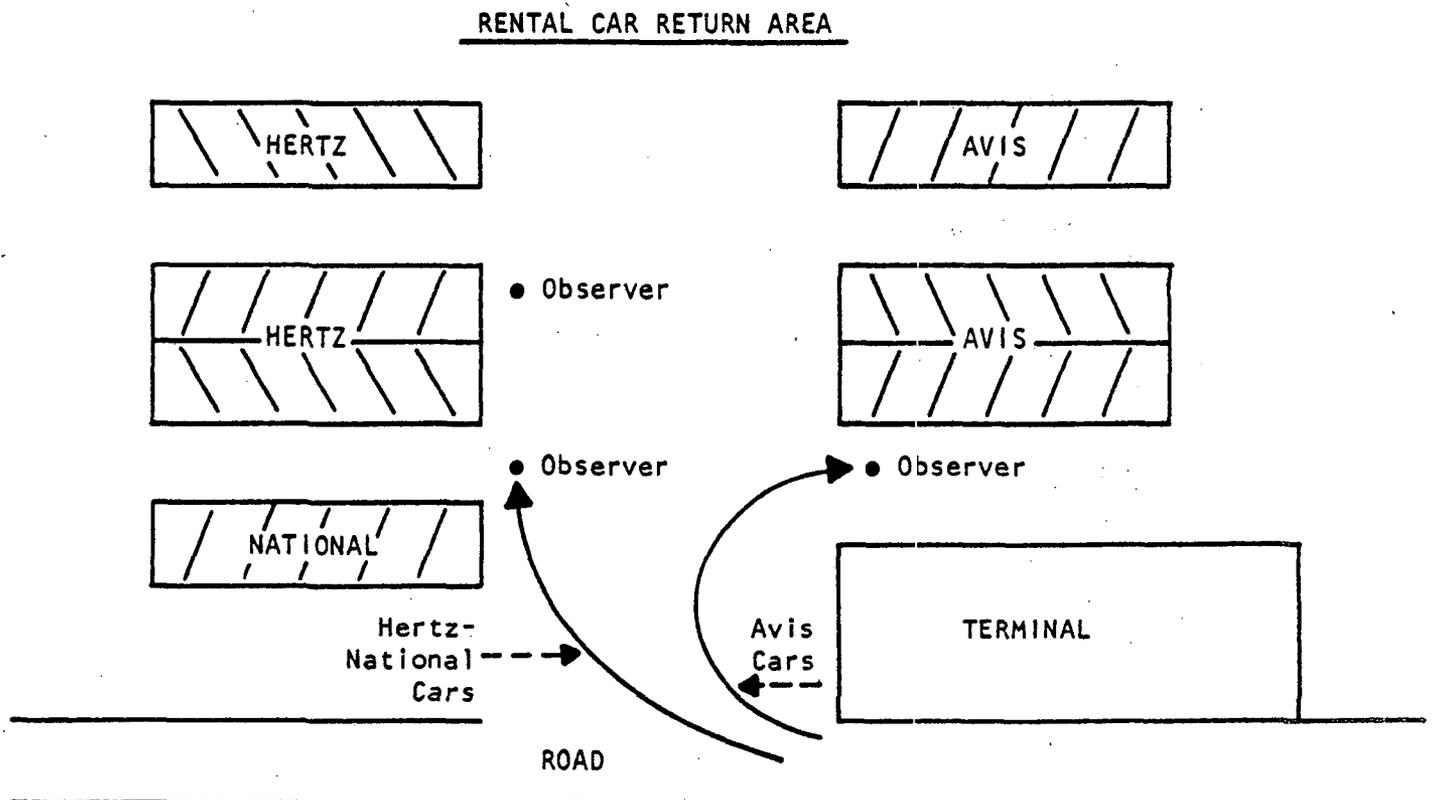
Type System:	Percent Observed Usage Lap and Shoulder or Lap Only			
	<u>N</u>	<u>Includes Terminal Stops</u>	<u>N</u>	<u>Excludes Terminal Stops</u>
1. No W.S. operating	1,190	14.6	867	16.5
2. 7-8 sec buz, seq, cont lt	521	23.2	358	26.0
3. 7-8 sec seq, inter buz, cont fl lt	881	22.9	603	27.4
4. 7-8 sec lt & buz, both seq	724	15.8	488	18.0
5. 1975 W.S. (7-8 sec duration)	523	13.9	370	16.7
6. 7-8 sec buz, cont lt	190	14.7	131	17.6
7. 1975 W.S. (4-5 sec duration)	576	12.8	406	13.7
Total	<u>4,605</u>		<u>3,223</u>	

(Drivers only)

After each observation of safety belt use, the observer went immediately to the returned car and inspected the use-inducing system to determine whether or not the system was operating as per contract specifications. This information was also recorded on the observation form. All observations for which the inspection showed the system not to be working properly were excluded from the study findings. The license number of the modified cars which were inspected and found to have inoperative use-inducing systems were turned over to the local supervisor for follow-up inspection and repair.

Below is a diagram of the rental car return area and the observation posts:

Figure 3



## ANALYSIS OF USAGE DATA

Separate results on usage are reported here for:

- Drivers vs. Passengers
- Make of Car
- Weight Class

As previously reported in the Summary, among the six use-inducing systems tested, the most effective included (1) a continuous light that does not go off unless the belt is fastened, (2) a buzzer that goes on for 7-8 seconds and then goes off if belt is not fastened, and (3) a sequential logic system that requires the driver to first sit on the seat and second buckle his belt (this latter feature is designed to prevent the belt from being buckled and tucked under the seat and left that way). The other systems tested show usage rates which are not significantly higher than the control group, i.e., vehicles with no operating warning system (Figure 1, page 2).

In the pages following, usage data for the two effective systems are compared with usage data for the control group by drivers vs. passengers, manufacturer, and weight class.

### Usage by Drivers vs. Passengers

The continuous light and a sequential logic system are equally effective for both drivers and front seat passengers. Figure 4 shows usage among drivers to be over eight percentage points higher in cars with the modified systems than in those with no operating systems. The same pattern is evident in Figure 5, which shows usage data for front seat passengers. In Figure 5, however, statistically significant differences are not apparent because of the small sample sizes. Nevertheless, the magnitude of the differences in the raw percentages suggests that the modified systems are as effective with passengers as they are with drivers.

Note: The rental cars at the Phoenix Airport were 1975 models which were purchased early in the model year. The safety belt warning systems in these earlier models were designed to operate for the front outboard passenger as well as for the driver.

Figure 4

## DRIVERS

	Percent Observed Usage		Total	N
	Lap and Shoulder	Lap Only		
No WS operating	13.1	+1.5	14.6	1,190
7-8 sec buz, seq, cont lt	21.1	+2.1	23.2 (S)	521
7-8 sec seq, inter buz, cont fl lt	21.1	+1.8	22.9 (S)	881

Figure 5

## PASSENGERS

	Percent Observed Usage		Total	N
	Lap and Shoulder	Lap Only		
No WS operating	11.3	+2.4	13.7	204
7-8 sec buz, seq, cont lt	25.8	0	25.8	62
7-8 sec seq, inter buz, cont fl lt	22.5	+1.2	23.7 (S)	169

S = Sig. higher than control

### Usage by Make of Car

Figures 6, 7, and 8 opposite compare, for each of the three manufacturers, usage for the two "effective" systems with that for the control group. The small sample sizes available for analysis do not permit meaningful conclusions in all cases. In Ford cars, both of the modified systems show significantly higher usage than the control group -- i.e., Ford cars with no operating warning systems. In both Chrysler and General Motors cars, a statistically significant difference is evident for one of the modified systems but not the other. Here again, however, the direction of the data strongly supports the general conclusion that a warning system which includes continuous light and sequential logic will enhance safety belt usage.

Figure 6

## USAGE BY MAKE OF CAR

<u>Chrysler</u>	Percent Observed Usage		<u>Total</u>	<u>N</u>
	<u>Lap and Shoulder</u>	<u>Lap Only</u>		
No WS operating	14.6	+1.2	15.8	507
7-8 sec buz, seq, cont lt	21.6	+1.5	23.1 (s)	199
7-8 sec seq, inter buz, cont fl lt	19.1	+2.3	21.4	308

Figure 7

<u>Ford</u>	Percent Observed Usage		<u>Total</u>	<u>N</u>
	<u>Lap and Shoulder</u>	<u>Lap Only</u>		
No WS operating	12.3	+1.5	13.8	473
7-8 sec buz, seq, cont lt	25.6	+2.3	27.9 (s)	219
7-8 sec seq, inter buz, cont fl lt	23.6	+1.7	25.3 (s)	467

Figure 8

<u>G.M.</u>	Percent Observed Usage		<u>Total</u>	<u>N</u>
	<u>Lap and Shoulder</u>	<u>Lap Only</u>		
No WS operating	11.5	+2.4	13.9	410
7-8 sec buz, seq, cont lt	16.8	+1.8	18.6	161
7-8 sec seq, inter buz, cont fl lt	20.4	+1.1	21.5 (s)	265

S = Sig. higher than control

### Usage by Weight Class

Safety belt usage (measured in terms of some protection) is almost twice the rate in compact cars with the continuous light and sequential logic system than in compact cars with no operating warning system. In the intermediate weight class, usage rates for the modified systems are also significantly higher than for the control group, but more on the order of one and one-half to one rather than two to one. The data for standard models are inconclusive. Neither of the modified systems shows a usage rate that is significantly above the usage rate for the control group.

Figure 9

## USAGE BY WEIGHT CLASS

<u>Compact</u>	Percent Observed Usage		<u>Total</u>	<u>N</u>
	<u>Lap and Shoulder</u>	<u>Lap Only</u>		
No WS operating	13.3	+1.3	14.6	467
7-8 sec buz, seq, cont lt	27.3		27.3 (S)	143
7-8 sec seq, inter buz, cont fl lt	26.3	+1.7	28.0 (S)	346

Figure 10

<u>Intermediate</u>	Percent Observed Usage		<u>Total</u>	<u>N</u>
	<u>Lap and Shoulder</u>	<u>Lap Only</u>		
No WS operating	11.7	+2.0	13.7	655
7-8 sec buz, seq, cont lt	20.0	+2.2	22.2 (S)	270
7-8 sec seq, inter buz, cont fl lt	20.4	+2.4	22.8 (S)	412

Figure 11

<u>Standard</u>	Percent Observed Usage		<u>Total</u>	<u>N</u>
	<u>Lap and Shoulder</u>	<u>Lap Only</u>		
No WS operating	14.7	+1.5	16.2	265
7-8 sec buz, seq, cont lt	19.9	+3.0	22.9	166
7-8 sec seq, inter buz, cont fl lt	17.1	+0.7	17.8	280

S = Sig. higher than control

## SUMMARY AND CONCLUSIONS

This observation study among rental car customers conducted at the Sky Harbor Airport, Phoenix, Arizona, had the following two basic objectives:

- (1) To determine if the warning system now required on 1975 and 1976 cars is effective in increasing usage, and
- (2) To determine the effectiveness of various other types of warning systems allowable under P.L. 93-492.

The survey findings indicate that the warning system now on 1975 cars, which consists of a light and buzzer that goes off automatically after 4-8 seconds regardless of whether or not the belts are fastened, is not effective in increasing usage. The usage rate for this warning system is not significantly greater than that for cars containing no operating warning systems.

Among six use-inducing systems studied, only two were found to have any measurable effect in terms of increasing belt usage. Each of the effective systems has characteristics which differ from the other systems studied in two respects:

- (1) A reminder light that goes on and stays on until the belt is fastened
- (2) A sequential logic system that requires the driver to first be seated and second to buckle his belt. This latter feature makes it less likely that the belt will be buckled and left that way.

The two warning systems differ only with respect to the light and buzzer. One of the systems was designed to include a flashing light and a buzzer with intermittent sound. The other system utilized the standard light and buzzer. Both systems were found to be equally effective.

Among rental car customers, usage in terms of some protection (lap and shoulder or lap only) was 12.8% for the 1975 warning system compared with 23.5% for the winning combination, i.e., the continuous light and sequential logic system. Thus, the latter system increased usage on the order of 84%.

Usage data based on rental car customers cannot be projected with precision to the general population of drivers. Rental car customers tend to be predominantly men on business trips driving a car which they do not own. It is reasonable to assume, however, that had all 1975 model cars been equipped with a continuous light and sequential logic system rather than the 1975 warning system required by the new Standard 208, the usage rate among the general population of drivers would have experienced, as a minimum, an increase of the magnitude evident in the rental car study.